

which was already migrating in, presumably from the north. It is reasonable to suppose that this fauna, in turn, was modified by the renewed uplift of late Eocene or Oligocene time.

SNAILS AS HOSTS AND CARRIERS OF NEMATODES AND NEMATOMORPHA

B. G. CHITWOOD

Zool. Div. Bur. Animal Industry, U. S. Dept. Agric.

and

M. B. CHITWOOD

Glencarlyn, Va.

Snails, in their rôle as intermediate hosts of parasites, are generally thought of as hosts of trematodes, more especially because some of these trematodes are of considerable economic importance. However, snails are also of considerable interest as hosts of nematodes. The nematode fauna of snails received attention from helminthologists at an early date, but the subject was subsequently rather neglected until within the past two years. Such peculiar phenomena as the ability of so-called "free-living" and plant-parasitic nematodes to survive passage through the intestine of snails, and the occurrence in snails of nematodes belonging to the same genera as nematodes found in Amphibia, have raised interesting problems in the host-parasite relationships of these nematodes.

This problem in snail-nematode relationship may be attacked, first, by separating the nematodes found in snails into six groups on the basis of the mode of life of the nematodes involved. These six groups are as follows: (1) Nematodes normally free-living (living upon decaying plant or animal matter) and plant parasites which may pass through the digestive tract uninjured; (2) nematodes living as obligatory parasites in the digestive tract; (3) nematodes living as parasitic larvae in the foot muscle and having a free-living adult stage; (4) adult nematodes living in the genital organs; (5) agamic nematodes and Nematomorpha which live in the body cavity and leave the host upon reaching maturity, subsequently passing the remainder of their life as

free-living forms; and (6) nematode parasites of vertebrates, the larval stages of which nematodes occur in snails. These groups are now taken up individually.

1. The members of the first group are free-living and plant-parasitic nematodes. They are usually rather small, from 400 μ to 2 mm. long. Since they do not, under ordinary conditions, pass any part of their life in the snail, their association with snails can best be considered as facultative or causal parasitism. The first observation of this type of snail-nematode relationship was made by Schneider (1859), who described *Leptodera foecunda* (= *Pelodytes hermaphroditus*) from the slime of *Arion empiricorum*. The presence of free-living nematodes in the digestive tract of snails was first mentioned by Cobb (1888). This writer expressed the opinion that the digestive fluids of the snail were not sufficiently strong to injure free-living nematodes. He listed the following nematodes from the feces of the "Weinberg-schnecke" (*Helix pomatia*): *Aphelenchus parietinus*, *Tylenchus filiformis*, *Cephalobus elongatus*, *Rhabditis dolichura*, and *Tylenchus lameliferus*. These nematodes, in so far as can be determined from Cobb's brief discussion, were not found encysted or ensheathed. The first report of an encysted nematode was that of Maupas (1899) who described as *Rhabditis causanelli* a nematode which he found encysted in the intestine of *Arion empiricorum* v. *ater*, *Arion ater* (L.) (syn. *A. empiricorum* Fér.); he obtained the adult stage of this nematode by culturing the larvae in decaying organic matter.

The present writers have found *Pathoaphelenchus parietinus* (= *Aphelenchus parietinus*) and *Cephalobus elongatus* to be rather common in the intestine of *Philomycus dorsalis* in that part of Virginia bordering on the District of Columbia. *Pathoaphelenchus parietinus* is a plant parasite which normally inhabits the buds and leaves of a wide variety of plants, and may cause considerable damage to a host plant. *Cephalobus elongatus* is capable of living free in the soil, but is also common in diseased plants and has been considered in some instances a secondary invader of plant tissue. Three other species of nematodes found by the writers in the intestines of *Polygyra albolabris* in the region of Glencarlyn, Va., are as follows: *Aphelenchus avenae*, normally

associated with plants, and *Acrobeloides minor* and *Rhabditis monhystera*, both of which are generally found in decaying vegetable matter.

In the above instances discovered by the writers the association of the nematodes with the snails appears to be purely accidental and cannot be considered a necessary association, *i.e.*, parasitism; nevertheless, this association may be of some significance, for snails must be considered as possible carriers of plant parasites and may play a rôle in the spread of plant diseases caused by nematodes. This type of snail-nematode relationship should certainly be considered in connection with experimental work on plant diseases.

2. The second group, obligatory parasites living in the intestinal tract of snails, contains representatives of two families of nematodes, the Angiostomidae and Cosmocercidae. There is at present but one known representative of the Angiostomidae in snails, namely, *Angiostoma limacis*. This species was first described by Dujardin (1845) from the intestine of *Limax rufus* (s.o. *Arion ater* vide Taylor, 1907) and later redescribed by Schneider (1866) as *Leptodera angiostoma* (= *Angiostoma limacis*) from the intestine of *Limax ater* (s.l. *Arion ater* vide Taylor, 1907). It may be interesting to note in this connection that the senior writer has found a species very closely related to *Angiostoma limacis* in the intestine of a salamander, *Plethodon cinereus*.

The writers have collected members of the Cosmocercidae, from two species of small hosts, *Opeas goodalli* and *Deroceras agreste*, which were obtained from the greenhouses of the U. S. Department of Agriculture. These species appear to belong to the genus *Cosmocercoides* Wilkie, 1930. The adults inhabit the intestinal tract of the host; the larvae were found in the eggs of the slug, *Deroceras agreste*. These larvae agree in all respects with those described from the egg of "limace grise" (the grey slug) by Barthelmy (1858), to which larvae he applied the name *Ascaroides limacis*. On the basis of this evidence it appears possible that *Ascaroides limacis* may belong in the family Cosmocercidae, but it is impossible to identify the form in question with existing genera or species of that family owing to the absence of a description of the adult stage.

Another representative of the Cosmocercidae, *Trionchonema rusticum*,¹ was described by Kreis (1932) from *Polygyra espicicola* (s.o. *P. espiloca*).

The species *Ascaris cylindrica*, which Leidy (1849) described from the intestine of *Helix alternata* (s.o. *Anguispira alternata*) and *Angiostoma helicis*, and which Conte and Bonnet (1903) described from the gonads and gonoducts of *Helix aspersa*, also appears to be most closely related to the Cosmocercidae so far as can be judged from available descriptions of this form.

The genus *Cosmocercoides* as well as other genera of the family Cosmocercidae are generally known as parasites of amphibians and reptiles. It is not uncommon for invertebrates to serve as intermediate hosts of vertebrate parasites, but *Angiostoma* and *Cosmocercoides* appear to be the first genera of nematodes known to contain species which are parasites both of vertebrates and invertebrates. The similarities of habitat of snails and salamanders may in part explain the presence of the adult stage of members of the group in both types of host.

3. The third group, parasites living as larvae in the foot-muscle and having a free-living adult stage, contains a single representative *Alloionema appendiculata* Schneider (1859). This species was first described from *Arion ater*, and was later refigured and redescribed in considerable detail by Claus (1868). *Alloionema appendiculata* has not been observed in recent years and its systematic position is still uncertain.

4. The fourth group, adult nematodes living in the genital organs, likewise contains but a single representative, *Leptodera flexilis* Dujardin, 1845. It was originally reported from *Limax cinereus*.

5. The fifth group, nematodes and Nematomorpha, which live as agamic forms in the body cavity and leave the host upon reaching sexual maturity, contains several representatives, as follows: *Gordius aquaticus* from *Lymnaea* sp. *L. vulgaris* and *L. ovata*; *Gordius villoti* from *L. ovata*; *Paragordius tricuspidatus* from *L. ovata*; *Parachordodes tolosanus* from *Lymnaea* sp.; *Mermis nigrescens* from *Limax agrestis* (s.o. *Deroceras agrestis*); and *Mermis albicans* from *Succinea putris*.

¹ The genus *Trionchonema* Kreis (1932) appears to be a synonym of *Cosmocercoides* Wilkie, 1930.

6. Of the sixth group, larval stages of nematodes the adults of which are parasites of vertebrates, only one species is known, namely, *Müllerius capillaris*. Hobmaier and Hobmaier (1929 and 1930) have reported this species from the following hosts: *Limax cinereus*, *L. flavus*, *Agriolimax agrestis* (s.o. *Deroceras agreste*), *Arion circumscriptus*, *A. empiricorum*, *A. hortensis*, *A. subfuscus*, *Helix hortensis*, *H. pomatia*, *Succinea putris*, *S. pfefferi*, *Hygromia (Fruticicola) hispida*, *Monacha umbrosa* (s.o. *Hygromia umbrosa*), *M. bidens*, *Cepaea hortensis* (s.o. *Helix hortensis*), *Cingulifera planospira*, *Helicigona (Chilostoma) planospira* and *Helicigona (Arianta) arbustorum*. *Müllerius capillaris* in the adult stage is an economically important parasite of sheep. It would be rather surprising if future investigations do not disclose the fact that snails can serve as intermediate hosts for many nematode parasites of vertebrates.

In addition to the above records there are a few nematodes from snails concerning which so little is known that the writers hesitate to place them in any of the above groups. They are as follows: *Dubium Rudolphi*, 1819, from *Helix nutris* (= (?) *Succinea putris*); *Phacelura paludinae* Ehrenburg in Hemprich and Ehrenburg, 1828, from *Bythinia tentaculata* and *Vivipara vera*; *Phacelura inquilina* (Müller, 1774) Diesing, 1851, from *Lymnaea auricularia*, *Physa fontinalis*, and *Planorbis corneus*; and *Phacelura lymnaei* Diesing, 1851 (= *Filaria lymnaei-stagnalis* Diesing 1851), from *Lymnaea stagnalis*.

The writers are at present continuing investigations on the nematode fauna of molluscs and would appreciate aid from malacologists either in the form of living hosts or preserved nematodes obtained from snails.

REFERENCES

Barthelmy, M. A. 1858.—Études sur le développement et les migrations d'un nématode parasite de l'oeuf de la limace grise. Ann. d. sc. nat. Par., Zool., 5s, v. 10 (1) : 41-48.

Claus, F. W. 1868.—Beobachtungen über die Organisation und Fortpflanzung von *Leptodera appendiculata*. Schrift. d. Gesellsch. z. Beförd. d. ges. Naturw. zu Marburg. Suppl. Heft 3, 24 pp., 3 pls., figs. 1-31.

Cobb, N. A. 1888.—Beiträge zur Anatomie und Ontogenie der Nematoden. pp. 1-36. Jena.

Conte, A., and Bonnet, A. 1903.—Sur un nématode nouveau *Angiostoma hélicis* n. sp., Parasite de l'appareil genital d'*Helix aspersa* (Müll.) Ann. Soc. Linn. de Lyon. n. s. v. 50: 63-68.

Dujardin, F. 1845.—Histoire naturelle des helminthes ou vers intestinaux. xvi + 654 + 15 pp.

Hobmaier, A., and Hobmaier, M. 1929.—Über die Entwicklung des Lungenwurmes *Synthetocaulus capillaris* in Nackt-, Weg-, und Schnirkelschnecke. München. Tierärztl. Wehnschr. v. 80 (36): 497-500. 1930.—*Limax* und *Succinia*, zwei neue Zwischen-Wirte von *Müllerius* (*Synthetocaulus*) *capillaris* des Schafes und der Ziege. München. tierärztl. Wehnschr. v. 81 (23): 1-8.

Kreis, H. A. 1932.—*Trionchonema rusticum* n. g., n. sp., a parasitic nematode from the land snail, *Polygyra espicola* Bland (Helicidae). Tr. Am. Micr. Soc., v. 51 (1): 48-56.

Leidy, J. 1849.—[New genera and species of Entozoa]. Proc. Acad. Nat. Sc. Phila. v. 4 (11): 229-233.

Maupas, E. 1899.—La mue et l'enkystement chez les nématodes. Arch. d. zool. expériment. et gén. Ser. 3, v. 7: 563-628.

Schneider, A. 1859. Über eine Nematodenlarva und gewisse Verschiedenheiten in den Geschlechtsorganen der Nematoden. Ztschr. f. wissenschaft. Zool., v. 10 (1): 176-178. 1866.—Monographie der Nematoden. viii + 357 pp., Berlin.

BIBLIOGRAPHY OF WILLIAM GREENE BINNEY

BY ARTHUR F. GRAY

(concluded from p. 101)

22. Check List of the Shells of North America, Terrestrial Gasteropods, by W. G. Binney. (No date.) Smithsonian Misc. Coll., pp. 45-50. Second Edition. (Section I. Pacific Coast, Section II. Eastern North America, and Section III. Mexico.)

23. Check List of the Shells of North America—Fluviatile Gasteropoda, by W. G. Binney. (No date.) Smithsonian Misc. Coll., pp. 51-57.

24. Catalogue of Land and Fresh-water Univalve Mollusks collected in British America, by Messrs. Ross, Kennicott and Drexler, and deposited in the Smithsonian Collection, Proc. Acad. Nat. Sci. Philadelphia, Oct., 1861, p. 330.

25. Notes on the Terrestrial Mollusks of the Peninsula of California. Proc. Acad. Nat. Sci. Philadelphia, Oct., 1861, pp. 331-333, with wood-cuts. (New species described are *Bulimus Xantusi*, *B. artemisia*, *B. pilula*, and *B. inscendens*.) Also published separately.